Impulsivity does not Moderate the Relationship between Attentional Bias and Stimulus Control

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Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

Signature: .... **Date:** 17th October 2019 **...............................**

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Table of Contents

List of Tables and Figures

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Abstract

Researchers have been increasingly interested in the role that attentional bias to food cues plays in obesity. While some researchers have documented a positive association between attentional bias to food cues and obesity, other studies have failed to find such a relationship. Theory suggests that attentional bias and stimulus control are linked but recent work by our lab failed to observe the theorised positive association between these variables during real-world eating. This may have been because executive functions such as levels of impulsivity were not accounted for. This research investigated the role of impulsivity as a moderator for the relationship between attentional bias and stimulus control. After completing the Barratt Impulsiveness Scale to assess impulsivity levels, and a visual probe task to assess attentional bias, participants (*N* = 70) monitored their eating for 14 days as they went about their daily lives. Results did not support impulsivity as a moderator for the relationship between attentional bias and stimulus control. Nor was there a correlation between attentional bias and stimulus control. Study outcomes may have been limited by the measurements employed, particularly in relation to attentional bias. Future research should focus on standardising measures for and definitions of, attentional bias.

Keywords: attentional bias, obesity, stimulus control, impulsivity, eating

There is currently a global obesity pandemic (Swinburn et al., 2011). Recent estimates suggest that rates of obesity (Body Mass Index [BMI] of $\geq$30 kg/m^2) and overweight (BMI or 25.0 – 29.99 kg/m^2) have tripled since 1975 in both developed and developing countries, with nearly 39% of adults now overweight and 13% obese (World Health Organisation (WHO), 2018). In 2017-18, an estimated 67% of Australians aged $\geq$18 were overweight or obese (Australian Institute of Health & Welfare [AIHW], 2018). It is predicted that by the year 2025, these rates will have risen to 72% of the Australian population (PricewaterhouseCoopers, 2015). The rising trend of obesity is concerning because of the associated health outcomes. Obese individuals are at risk of developing medical conditions such as type II diabetes, cardiovascular disease and certain varieties of cancer including: colorectal and prostate in men, and breast and endometrial in women (Khaodhiar, McCowen, & Blackburn, 1999). This is in addition to psychological conditions such as depression and poor self-esteem resulting from social stigmatization and discrimination (Wardle & Cook, 2005). Furthermore, extreme obesity, defined as having a BMI $\geq$ 35, is associated with decreased life expectancy and poor quality of life, irrespective of factors such as age, ethnicity, geographic location or rates of physical activity (Jarolimova, Tagoni, & Stern, 2013).

In addition to the impact on personal well-being, obesity-related health issues place considerable financial strain on the Australian economy, both directly and indirectly, with an estimated $8.6 billion spent in 2011-12 (AIHW; 2017). Using an index that factors in not just health and longevity, but also how successful Australia is in preventing avoidable health issues, it has been estimated that costs may actually stretch to $120 billion per year; this is equivalent to approximately 9% of the annual economic output (Lateral Economics, 2011; Obesity Policy Coalition (OPC), 2017). Because of the extensive health and financial costs related to obesity, it has become imperative that effective prevention and intervention strategies be developed and implemented; not just for the individual, but also for communities and populations across the globe (Tsigos et al., 2008). For this to occur, however, it becomes necessary to understand why people eat and, more specifically, why they eat to excess.

The most intuitive explanation is that people eat in response to hunger. Traditional biological models have emphasised eating as a means of restoring energy homeostasis or balance (Hopkins, Blundell, Halfird, King, & Finlayson, 2016; Weingarten, 1985). Typically, biological models suggest that homeostatic eating is stimulated and inhibited by internal monitoring systems that drive and supress hunger, the exclusive purpose of these systems is to regulate the internal environment with respect to the repletion of energy stores and tissue growth (Hopkins et al., 2016). In other words, hunger was conceptualised as the result of an empty stomach. Assuming it was available, food would be consumed until the stomach was full and the individual satiated, causing the cessation of eating (Woods and Ramsey, 2011). The general consensus within the literature is that obesity is caused by a sustained imbalance in the energy equation (i.e. energy intake surpassing energy expenditure; e.g., Ghanemi, Yoshioka, & St-Amand, 2018; Sharma & Padwal, 2009, Spiegelman & Flier, 2001). The proclivity for obesity is not a new feature of human biology, yet it is only within the last three decades (WHO, 2018) that it has emerged on a large and global scale (Spiegelman & Flier, 2001). This suggests that factors other than true homeostatic hunger are also driving eating (AIHW, 2017) and might go some way to explaining why obesity interventions focusing exclusively on caloric restriction have had limited success (Budewig et al., 2004).

In addition to energy requirements, an increasing degree of human food consumption seems to be motivated by pleasure. Like other hedonistically-driven activities such as drug use and gambling, appetite also appears to be associated with the rewarding properties of certain stimuli. Humans are biologically programmed to seek out energy dense and highly palatable foods (Lowe & Butryn, 2007). However, in today's obesogenic environment (the concept of an "obesogenic environment" appears frequently within the scientific discourse and can be defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations"; Lake & Townshend, 2006), that tendency has intensified (Lowe & Butryn, 2007). While homeostatic and hedonic are both forms of hunger, they should be understood as representing polar ends of a continuum. Homeostatic hunger is largely (but not exclusively) inspired by need, and hedonic is inspired largely (but not exclusively) by want (Lowe & Butryn, 2007; Miller, 2016). It should be noted, however, that in both instances, the individual eats in response to an actual hunger for food. Hedonic and homeostatic hungers do not fully account for another significant contributor to food consumption, namely cued hunger.

Stimulus Control

Food-related cues such as the sight or smell of food, advertisements, time intervals, or some other initially innocuous cue, may eventually come to signal the availability of food, and have been demonstrated to elicit unplanned [over]eating of highly palatable, energy-dense foods in food-sated adults and children (Cornell, Rodin, & Weingarten, 1989; Johnson, 2013). The relationship between environmental cues and the learned behavioural response (i.e., eating), can be recognised as a form of *stimulus control* (Weingarten, 1985). External stimuli previously linked with food consumption (and its associated pleasure), are automatically processed, eliciting a desire to eat *that* specific food, rather than a general state of hunger (Rogers, 1999; Weingarten, 1985). Stimulus control can work on multiple levels. For example, the aroma of freshly baked French pastries can trigger the resulting behaviour of visiting a patisserie. However, even the *memory* of a French pastry, (prompted by a photo of the Eiffel Tower), can cue a visit to the patisserie (Watson, Wiers, Hommel, Gerdes, & de Wit, 2017). A number of studies have demonstrated the power of food (sights and smells) to stimulate specific cravings and portion size, followed by actual consumption (e.g., Ferriday & Brunstrom, 2008; Sobik, Hutchison, & Craighead, 2005), as well as certain physiological forms of cue-responsiveness including salivation (e.g., Mattes, 1997; Nederkoorn, Smulders, & Jansen, 2000). What the individual perceives as true (homeostatic) hunger, therefore, is really a craving; prompting them to then respond accordingly (Watson et al., 2017). In this way, stimulus control can be useful in understanding why some people are driven to consume an excess of energy dense, highly palatable foods; the food becomes the reward, and the associated cues become so salient, they serve as a kind of "motivational magnet", evoking a conditioned response (Berridge, Robinson, & Aldridge, 2009).

Attentional Bias

Although the exact cognitive processes underpinning stimulus control have yet to be determined, the general consensus within the literature is that it is associated with neural changes in brain reward circuitry (Sharma & Fulton, 2013; Wang et al., 2001). This means that theories which explain addiction in terms of drug-centric cue-reactivity and particularly the purely subjective sensation of craving (Nijs & Franken, 2012), might also apply to obesity. One paradigm commonly used to explain addiction is the incentive-sensitisation theory (Robinson & Berridge, 1993) which posits that rewards are both "liked" and "wanted", but that these processes are mediated by different circuitry of the brain. With respect to addiction, the psychological "wanting" (incentive salience) is facilitated by the more robust systems containing dopamine, while the "liking" or associated pleasure of consuming the reward is mediated by weaker, dopamine-free systems. This means that addiction is more about the incentive salience ("wanting"), prompted by associated cues, than the actual "liking" (Robinson & Berridge, 2001). It is thought that with repeated consumption of the drug of choice, a sensitisation of dopamine release in the circuitry of the mesolimbic system occurs; this release increases in size each time the drug is administered, so that over time the motivational value of the drug increases, potentially leading to an irresistible urge to consume the desired substance (i.e., food; Field, Werthman, Franken, Hofman, & Hogarth, 2016). Eventually, environmental cues associated with the substance consumption inherit "attention grabbing" qualities or "incentive salience". In accordance with associative learning theories this results in drug-associated cues acting as strong motivational forces that "grab attention, become attractive and wanted, and thus guide behaviour to the incentive" (see Figure 1; Robinson & Berridge, 1993, p. 261). Those individuals possessing a high substance (food or drug) cue responsiveness are said to demonstrate an *attentional bias* towards that cue (Nijs, Muris, Euser, & Franken, 2010b).

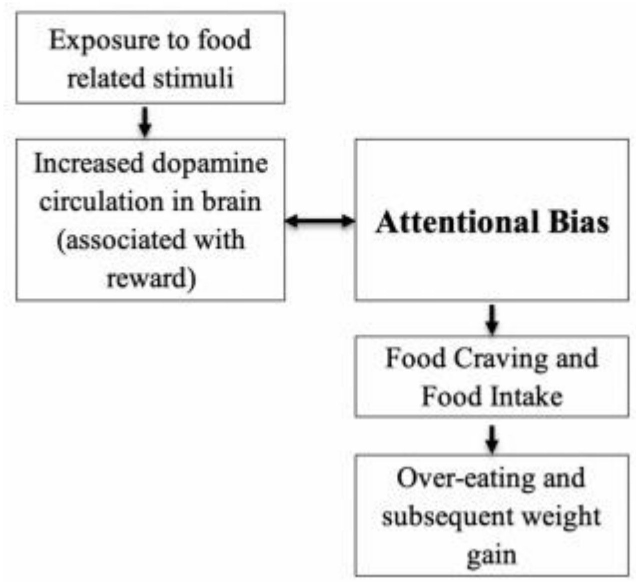

Figure 1. Theorised role of attentional bias in weight gain (adapted from Robinson & Berridge, 1993)

Attentional bias is of interest to obesity researchers because there is evidence to suggest that overweight and obese individuals are hypersensitive to food-related cues over non-food cues (for a full review see Hendrikse et al., 2015). Furthermore, there is a growing body of research to suggest an orientation of attention among obese individuals specifically towards high calorie (palatable) food over low-calorie (healthier) foods (e.g., Castellanos et al., 2009; Murdaugh, Cox, Cook & Weller, 2012; Yokum et al., 2011). Indeed, attentional bias has been used in some instances to predict future weight gain, and short and long-term successes in weight-loss programmes (Murdaugh et al., 2012; Yokum et al. 2012). For example, Calitri, Pothos, Tapper, Brunstrom, and Rogers (2010) reported that, after controlling for other variables typically associated with weight gain (such as physical exertion, stress, and reactive/emotional eating), attentional biases for healthy and unhealthy foods were predictive of BMI change across a 12-month period. These findings parallel the research on substance abuse and lend further credibility to the concept of cognitive biases being predictive of behavioural change. This is an important result because it implies that cognitive biases can be modified. If the subsequent behaviour changes a person can reduce their hypersensitivity to food cues, the ensuing behaviour; craving followed by eating, can, therefore, be curbed. Modification interventions for food-related attentional biases have been developed and at test condition, appear effective (see Brockmeyer, Hahn, Reetz, Schmidt, & Friedrich, 2015; Kakoschke, Kemps, & Tiggemann, 2014; Kemps, Tiggemann, & Hollitt, 2014). Studies typically employ implicit measures to gauge attentional bias to food stimuli. This is because the cognitive processes driving the biases and subsequent behaviours, are thought to occur automatically and are therefore difficult to control and assess via conscious introspection (Kemps & Tiggeman, 2015; Wiers, Teachman, & De Houwer, 2007). Common implicit measurements use indices such as eye-tracking, neural-circuitry and reaction times to determine attentional allocation to salient stimuli, i.e., food-related images and words (see Castellanos et al., 2009; Kemps & Tiggemann, 2009; Nijs et al., 2010a, Nijs et al., 2010b; Nijs & Franken, 2012; Nummenmaa, Hietanen, Calvo, & Hyönä, 2011; Yokum et al., 2012).

While a number of studies have positively associated BMI (specifically those in the obese range), with an elevated attentional bias towards food, these findings are not consistent.

Attentional bias is not always significantly and positively correlated with individual differences in body weight or food intake. Some studies, including a longitudinal, observational study conducted by members of this research team (see Franja, Elliston, Matthews, & Ferguson, 2018) have found little to no association at all (for example, see Field et al., 2016; Kaisari et al., 2018; Werthmann et al., 2011). One possible explanation for the inconsistency could be that the bulk of research into attentional bias and its relationship with eating patterns has been laboratory-based. Regardless of the measurement tool used, most studies follow a protocol of 1) obtain an attentional bias score, and 2) measure the likelihood of food consumption via a "taste-test" immediately after. It has been suggested, however, that there could be a link between attentional bias and the anticipation of an immediate reward, e.g., a taste test (Jędras, Jones, Stancak, & Field, 2019; Nijs et al., 2010a). As such, there exists the possibility that the relationship between attentional bias and food intake, as demonstrated within a laboratory setting, is not truly reflective of the "real" world, and therefore needs to be interpreted with an understanding of some limited ecological validity. To improve on this, a previous study conducted by members of this research team explored the relationship between attentional bias and stimulus control within a real-world context; via the use of ecological momentary assessment (EMA) technology (Franja et al., 2018). Somewhat surprisingly, however, there was still no apparent correlation between a heightened responsiveness to food cues and eating. One possible reason for this could be that the role of executive (controlled) functions such as impulsivity were not accounted for.

Impulsivity

Broadly speaking, executive functions describe a set of top-down cognitive processes necessary for driving goal-directed behaviours when acting automatically or instinctively would be inappropriate or inadvisable (Miller & Cohen, 2001; Kulendran, Vlaev, Gamboa, & Darzi, 2017). This involves organising, checking and adjusting the setting of secondary level cognitive processes such as stimulus detection and motor programming (Kulendran et al., 2017; Logan 2003). A person's level of restraint (i.e., inhibitory control) may be conceptualised as the overriding of a planned action or the cessation of an action already underway, for example stimulus response or reward seeking (Bari & Robbins, 2013). In the context of food cues and eating, impaired inhibitory control (or elevated impulsivity) can manifest as strong impulses or cravings to eat, leading to un-planned eating and potential weight-gain (Appelhans, 2009). Conversely, reduced impulsivity can manifest as the ability to resist indulging in palatable, high-calorie foods in deference to the maintenance of long-term personal goals such as dieting or weight loss (Houben & Jansen, 2011). Impulsivity is experimentally measured using standardised behavioural methods (measuring an individual's ability to suppress a prepotent motor response; Spechler et al., 2016) as well as self-report measures (based on self-assessment of rapid and ill-considered behaviours; Enticott, Olgoff, & Bradshaw, 2006). Using these methods, some studies have reported findings to suggest that elevated impulsivity and reduced inhibitory control are associated with: excess consumption (e.g., Guerrier et al., 2007), comfort eating (e.g., Bekker, van de Meerendonk, & Mollerus, 2004), and overweight/obesity (e.g., Guerrieri, Nederkoorn, & Jensen, 2008; Nederkoorn Jansesn, Mulkens, & Jansesn, 2007; Spitoni et al., 2017). The interplay of the mechanisms underpinning these findings, however, remains ill-defined (Nederkoorn, Smulders, Havermans, Roefs, & Jansesn, 2006).

Previously within this paper, the relationship between attentional bias and stimulus control was explained in terms of hedonic feeding and the incentive-sensitisation model of addiction (Berridge & Robinson, 2016; Berridge, et al., 2009). The explanation offered thus far, however, does not account for one important piece of information; which is, why some individuals demonstrating high levels of attentional bias to food cues are able to abstain (frequently or occasionally) from consuming the desired food, while others cannot. Some theorists have posited that impulsivity serves as a moderator for the effects of attentional bias on behavioural outcomes, explaining the relationship in terms of a dual process model of behaviour. These models propose that behaviour is the joint outcome of two separate information processing systems; automatic (bottom-up) and controlled (top-down) (Appelhans, 2009; Strack & Deutsch, 2004). Automatic, bottom-up processing is fast, intuitive and without consideration, and is based on affective and motivational responses to attention-grabbing stimuli (e.g., food cues). Conversely, controlled, top-down processing is reflective, slow and involves explicit, deliberate actions based on personal goals or standards, e.g., dieting and weight loss (Kakoschke, Kemps & Tiggeman, 2015a). Controlled and automatic processing systems produce contradictory messages; the dominance of one system over the other determines the behavioural outcome. Ideally (if cognitive resources are on hand), the controlled processing system would regulate the automatic system in guiding behaviour. For example, if a person is presented with palatable but unhealthy food cues and is on a diet, there may arise an internal conflict between the automatic system, which is implicitly drawn to such cues, and the controlled processing system, which maintains a desire to lose weight. A weak controlled processing system (heightened impulsivity) paired with a stronger automatic system (attentional bias to food cues) would then result in the [over]consumption of unhealthy foods (see Figure 2; Kakoschke et al., 2015b).

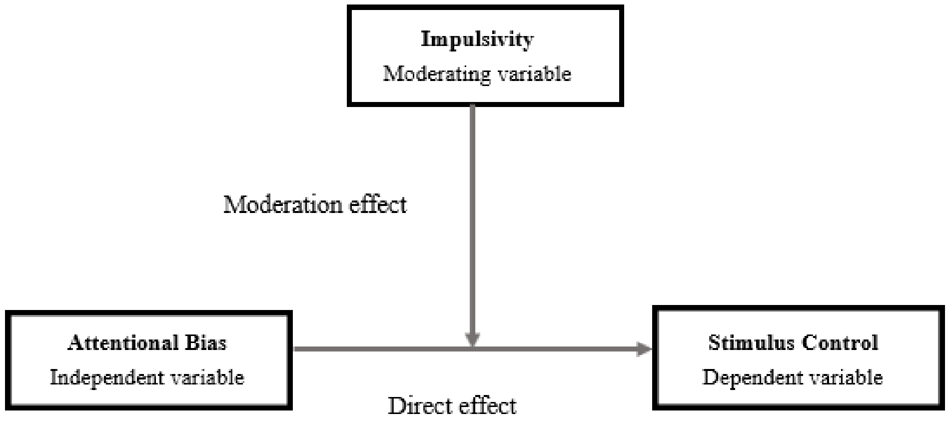

Figure 2. Impulsivity as a moderator for attentional bias and stimulus control

Influence of Attentional Bias and Impulsivity on Real-World Eating

While there is a reasonable body of experimental evidence to suggest that impulsivity might have a moderating effect on attentional bias and stimulus control (e.g., Meule, Lutz, Vögele, & Kübler, 2014; Meule & Platte, 2016), particularly in terms of predicting weight loss (individuals with high impulsivity and a hedonic approach to food consumption were less successful in weight reduction; Brockmeyer et al., 2016), there is little to no evidence to suggest how these findings might generalise to the “real-world”. As with the findings on attentional bias to food cues, to date all of the research gathered on the role of impulsivity as a moderator has been determined within a laboratory setting. Furthermore, task design and measurement techniques differed widely across studies, and may also indirectly measure other processes such as conflict resolution and response selection, thus limiting comparability of results, and the practical application of such findings (Luijten et al., 2014).

Methodological Issues

Ecological momentary assessment (EMA; Shiffman, Stone, & Hufford, 2008) methods can improve on the ecological validity of laboratory-based tasks or retrospective reporting by exploring the effects of the environment on real-world eating patterns. Traditionally, studies on impulsivity and attentional bias to food cues, have not taken into consideration the scope of influence a person's momentary food environment can have on food consumption; particularly among those with overweight or obesity (Elliston, Ferguson, Schüz, & Schüz, 2016). This means that the influences outside a person's immediate environment, e.g., workplaces, shopping precincts and schools, have been largely ignored (Ball & Thornton, 2013). Studies using EMA have further verified the relationship between the environment and eating behaviours by providing evidence to suggest that food intake is frequently cue-dependant (e.g., Elliston et al., 2016; Schüz, Bower, & Ferguson, 2015). Additionally, this same method has been used to corroborate laboratory findings suggesting that everyday snacking behaviour (discretionary food intake) is associated with a greater impact of social cues and a higher BMI (Schüz, Revell, Hills, Schüz, & Ferguson, 2017). However, since eating is generally context-dependant, and cued eating seems especially idiosyncratic in terms of individual responsiveness, it becomes necessary to observe people in their natural environment, where a variety of previously established cues, of which the participants may not even be aware, exist (Elliston et al., 2016; Schüz, Schüz, & Ferguson, 2015; Wood & Neal, 2007). Therefore, in order to obtain a more holistic picture, this study employs EMA.

An EMA study requires its participants to have on hand at all times (for an allocated period), a device that acts as an electronic diary. Participants use the device to record all instances of food and drink consumption, and to respond to related questions pertaining to their moods, situations and activities during times of eating and for comparative purposes, participants also respond to intermittent prompts on instances of not-eating (Grenard et al., 2013). This is done in real time i.e., the "momentary" component of EMA (rather than retrospectively,) and repeatedly during the day (Shiffman et al., 2008). The data collected can then be generalised to the real lives of the participants (i.e., the “ecological” component), thus allowing a picture to emerge of how behaviour changes over time and circumstance (Grenard et al., 2013).

The momentary assessment component of EMA is another key feature in this form of methodology. In contrast to paper diaries, which rely on autobiographical memory; demonstrably inaccurate and biased (see Hyman & Loftus, 1998; Thomas & Diener, 1990), EMA studies allow for the real-time collection of information (i.e., food intake, quality of mood, and situational and contextual details), thus minimising the likelihood of mood-related recall (i.e., an individual’s present low mood may colour retrospections of lighter moods earlier in the day) which can ultimately skew the data (Shiffman et al., 2008). Additionally, EMA largely overcomes the issue of self-censorship, whereby participants under-report their energy intake; especially for high-calorie foods (Cook, Pryer, & Shetty, 2000). This is a common obstacle for many nutritional surveys and is particularly prevalent among women compared to men, and in overweight and obese populations (Macdiarmid & Blundell, 1998). It is likely that under-reporting is driven by a sense of social desirability; skipping breakfast or snacking on “junk” foods are not perceived as healthy and therefore reflect poorly on the individual (Fayet-Moore, Peters, McConnell, Petocz, & Eldridge, 2017). EMA overcomes the potential for this form of bias by allowing the participant to enter the information quickly into an electronic device, without having to recall and review individual items of unhealthy items consumed. In this sense, EMA methods are less confronting than traditional methods of self-report (Elliston, 2015).

EMA is an ecologically valid form of measurement (Moskowitz & Young, 2006; Shiffman et al., 2008) with reports being issued and completed on a daily basis within the individual’s usual environmental context. This makes it a true-to-life reflection of the participant’s own reality and allows for the study of microprocesses (triggers) influencing experiences, moods and patterns of behaviour (i.e., eating; Shiffman et al., 2008). This in turn reduces the likelihood of any demand characteristics (i.e., participants tailoring behaviours and responses to meet the perceived requirements of the researcher; McCambridge, Kypri, & Elbourne, 2014) that may be present when conducting research within a laboratory based setting.

Study Rationale

The relationship between attentional bias to food cues and cued eating patterns (stimulus control) has been alluded to within the literature. However, the evidence to suggest that a heightened sensitivity towards food cues may elicit cravings and subsequent food intake remains inconsistent. This may be because the majority of research has been conducted within a laboratory setting using a variety of methodology, BMIs categories, self-reported eating patterns (i.e., normal, restricted, binge) and experimental conditions (e.g., fasting, satiated). In accordance with the afore-mentioned dual-process model of behaviour, it may also be that other cognitive processes, such as impulsivity, are contributing to the outcome. Again, there is some evidence to suggest the role of impulsivity as a moderator for attentional bias to food cues and cued eating patterns; the idea being that impulsive reactions to food are linked to cue-elicited food craving (e.g., Meule, et al., 2014) . These studies have, however, also been largely laboratory based, utilised heterogenous study methods, small sample sizes, and consequently, do not reproduce well (Jones, Hardman, Lawrence & Field, 2018).

The purpose of this study is to investigate the proposed moderating effects of impulsivity on attentional bias and stimulus control outside of a laboratory setting. The findings of this study will contribute to the larger body of research on the development and implementation of interventions for weight loss and maintenance.

This study aims to address the present gaps in the literature and to improve on the ecological validity of previous studies by using EMA. In line with the incentive-sensitisation model of addiction and dual process models of behaviour, it is hypothesised that impulsivity will moderate the relationship between attentional bias and stimulus control. It is expected that lower levels of impulsivity (i.e., effective inhibitory control) will override high attentional bias scores to food cues, leading to lower levels of food intake and conversely, strong attentional bias scores paired with heightened impulsivity will lead to higher levels of food consumption

Method

Overview

The data for this thesis is drawn from a larger observational, longitudinal study conducted to examine cognitive and environmental predictors of food choices. The independent variable was attentional bias, the moderating variable was impulsivity, and the dependent variable was stimulus control. Participants completed three lab visits over two weeks. In addition to laboratory measures of attentional bias and inhibitory control, participants were also required to monitor their eating patterns using a study-issued electronic diary over 14 days. The study was granted approval by the Tasmanian Social Science Human Research Ethics Committee on May 3, 2019 (reference number H0018038; Appendix A). Prior to the commencement of any research proceedings, each participant provided written informed consent (Appendix B). Data collection extended from May 17, 2019 to August 21, 2019 and occurred at the University of Tasmania’s Launceston campus and Medical Sciences Precinct in Hobart.

Participants

Participants were recruited via a combination of flyers (Appendix C) around the University of Tasmania (Medical Sciences Precinct and Launceston campus), Hobart TAFE, public libraries and advertisements on social networking sites (e.g., Facebook). To be eligible for participation, individuals were required to be 18 years or over with a BMI of more than

18.5, not dieting, not previously diagnosed with an eating disorder, and proficient in the English language. Interested applicants who met these criteria were asked to supply their height and weight so that their BMI could be calculated. We used this BMI to ensure that the sample had approximately equal numbers of normal (n = 25; 35.71%), overweight (n = 20; 28.57%) and obese (n = 25; 35.71%) participants, as levels of impulsivity and attentional bias have been shown to positively correlate with BMI (e.g., Jones et al., 2018; Kulendran et al., 2017; Hendrikse et al., 2015).

Materials and Procedure

Initially, interested individuals completed a brief online screening questionnaire to assess for inclusion/exclusion criteria. Those deemed eligible were then invited in for the first of three laboratory visits; the enrolment session (~ 45 minutes long). During this visit, participants were asked to provide additional contact information and to complete a screening questionnaire; the Eating Attitudes Test (EAT-26; Garner, Olmsted, Bohr & Garfinkel, 1982). The EAT-26 is a standardised, self-report measure of symptoms and qualities reflective of eating disorders or issues related to food intake that might require professional consultation; examples of questions include: “I am terrified about being overweight”, response options: *always, usually, often, sometimes,* and *rarely*. In accordance with the scoring and interpretation recommendations of Garner et al. (1982), only individuals scoring less than 20 on the EAT-26 were eligible to participate, as higher scores (greater than 20) may be indicative of an eating disorder. The participant’s height and weight measurements were then taken to calculate their BMI. Following this, participants completed a survey assessing basic demographic information, e.g., socio-economic status, which was evaluated via standard Australian Bureau of Statistics (ABS) census questions, and the Barratt Impulsiveness Scale (BIS-11) to assess levels of impulsivity. During the enrolment session, participants were issued their study-specific Smartphone (EMA device) and received individual training on how to use the device a well as study protocol. During this time, participants were given the opportunity to practice logging food and drink reports and to ask any questions prior to the commencement of their data collection.

For the entire two-week period, real-time eating reports were assessed in two stages. For stage one, participants were asked to log every instance of meal, snack (categorised as Confectionery, Savoury, Fruits/Vegetables/Nuts, Dairy, Biscuits/Cakes/Pastries, Fast Food, or Other; sourced from the Dietary Targets Monitor (Lean, Anderson, Morrison, & Currall, 2003)), and drink consumption (excluding water). For everything that was logged, a time stamp was created detailing when the log had been completed. For stage two, a random subset (60%) of recorded snacks were sampled for a full assessment. Full assessment included questions pertaining to the participant's mood state, as well as current contextual and situational specifics. The device also issued participants with random prompts for instances of "not-eating" (i.e., non-event, *cf.* eating, which is the event). This served as a comparison for the presence of contextual cues during instances of eating as well as at random time points throughout the day. The information requested here was similar in nature to the full eating assessments and occurred ~ four times per day.

Between 7pm and midnight, participants were issued an "evening report" which gathered a retrospective assessment of their overall mood, cravings and exercise for the day. Completion of the evening report triggered the device's "bedtime" mode; an alarm like function which, when set, suspended random assessments until the specified time. At the set time, a "morning report" was issued, for which the participant provided information on their general mood, degree of alertness and any particular cravings currently experienced. Completing the "morning report" reinstated the flow of "random assessments" for the day. The information captured for the evening and morning reports, however, was not analysed for the present study.

Lab visit two (after ~2-3 days of monitoring) entailed a short compliance check during which the participant's data was uploaded from their study device and reviewed to ensure the participant had been adhering to study protocol i.e. food and drinks were being logged, "evening reports" completed and "random-assessments" answered. This was also an opportunity for the participant to ask any device/study-related questions, provide feedback and or receive any additional EMA training. Following this, participants completed an electronic and modified version of the Grand Hunger Scale (Loeber et al., 2012) to assess satiation as hunger has been linked to hypersensitivity to food cues and heightened impulsivity (Kakoschke et al., 2015b), before completing the computer-based cognitive tasks (described below).

During the third and final visit (scheduled for day 14), EMA device data was uploaded to a secure server on a password protected computer. Following this, participants were debriefed and given the opportunity to ask questions and provide feedback after receiving their reimbursement in the form of a $60 Coles Myer gift card.

Measurement Instruments

Visual probe task. Attentional bias for food cues was assessed using a modified version of MacLeod, Mathews, and Tata's (1986) visual probe task administered using Inquisit software (Inquisit 5, 2016). The probe paradigm is typically considered the "gold standard" for assessing an index of biased attention as determined by reaction times (Price et al., 2015; Thigpen et al., 2018). Although participants completed both lexical and pictorial versions of the task to assess food-specific attentional bias, only the results of the pictorial version were relevant to this study. In this case, images were selected as a more ecologically valid measure for attentional bias than text, as they more closely reflect real-world stimuli and may be more closely related to affective processing (De Houwer & Hermans, 1994;

Freijy, Mullan, & Sharpe, 2014). The results of the lexical probe task were incorporated into the findings of the larger, parent investigation to this study.

The visual component of the probe task was adapted from Miller and Fillmore's (2010) work on the attentional bias of drinkers towards alcohol-related images, and that of Kemps et al., (2014) on attentional bias for food cues in overweight and obese individuals. In this case, there were 20 coloured digital food images (e.g., fruit, salad, chocolate, lollies) and 60 animal images; the sorts of creatures typically appealing to Western ideals and not ordinarily consumed as part of the Western diet (e.g., cheetah, wolf, gorilla, dolphin). Images were paired and categorised as either *critical* (food - animal) or *control* (animal-animal). Pictures were matched specifically for their proximity in perceptual and conceptual characteristics. Participants were presented with a fixation cross positioned centrally on the screen for 500ms, followed by a pair of images, to the left and right of the cross, held again for 500ms. A probe ("X") would then appear in the position of either the left or right picture and participants were required to indicate, by pressing "E" (left) or "I" (right), which image had been replaced. Probes remained visible until a decision had been made; inter-trial times were also 500ms (see Figure 3.). For this task, there were 12 practice trials and 160 experimental. Trials were presented in a new, randomly selected order, per participant.

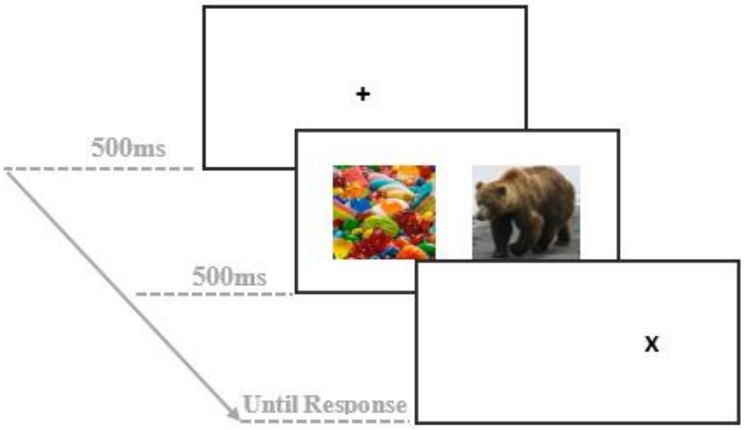

Figure 3. Visual probe task (Kemps et al., 2014)

Barratt Impulsiveness Scale (BIS-11). The Barratt Impulsiveness Scale, eleventh version (BIS-11; Patton, Stanford & Barrett, 1995) is a questionnaire designed to measure the behavioural construct of impulsivity. It is one of the most widely used self-report assessment tools of impulsivity, having been utilised within both a research and clinical setting for over fifty years (Stanford et al., 2009). The BIS-11 is a 30-item instrument conceptualising impulsivity as a multi-faceted construct with six primary subscales and three second order factors (McCarthy et al., 2015). The three subscales are 1. Attentional Impulsivity; with the emphasis on the (in)ability to focus (eight items; two of which are reversed scored to reflect non-impulsivity), 2. Motor Impulsivity; with the emphasis on action with(out) thought (11 items, one reverse-scored), and 3. Non-Planning Impulsivity; involving (a lack of) forethought (11 items; eight reverse-scored) (for a full review see Stanford et al., 2009). Examples of questionnaire items include: “I change hobbies” (attentional), “I act on impulse” (motor), and “I get easily bored when solving thought problems” (nonplanning). Items are rated on a four-point scale with one being “rarely / never”, and four being “[almost] always” Factor scores can either be assessed separately or totalled to provide an overall score; ranging from 30 to 120, with higher scores (>72; Stanford et al., 2009) indicating greater levels of impulsivity. The BIS-11 demonstrates sound internal consistency for its total score, with Cronbach's α alphas typically ranging from .79 to .83 (Patton et al., 1995). However, the three subscales demonstrate lower reliability, with Cronbach's α coefficients of 0.58 for Attentional Impulsivity, 0.57 for Motor Impulsivity, and 0.64 for Nonplanning Impulsivity (Bénard et al., 2017). Additionally, there is some conjecture within the literature as to which subset corresponds directly with a food-specific impulsivity (e.g., Meule and Platte, 2016, *cf.* Meule, de Zwaan, & Müller, 2017, *cf.* Oliva, Morys, Horstmann, Castiello, & Begliomini, 2019). Therefore, while the scores for the three subscales were calculated, only the BIS-11 total score was interpreted as pertinent to the current study.

EMA device. EMA assessment items were based on previous research exploring the momentary food environment and the role of cues in predicting everyday eating and drinking patterns (i.e., stimulus control; see Elliston, Ferguson, & Schüz, 2017; Elliston et al., 2016). All data was recorded via the EMA device's touch screen. For instances of both eating and non-eating, participants could be asked questions pertaining to their particular situation, the sort of activity they were engaged in, and if they were currently experiencing any particular food cravings. Specifically, external cues were assessed by having the participant respond to questions in a qualitative "yes (1)"/"no (0)" format. A full description of questions issued can be viewed in Appendix D (see also Appendix E for the EMA device user manual). Importantly, these forms of external cue assessments have previously indicated sound ecological validity in the prediction of eating patterns (e.g., Elliston et al., 2017; Schüz et al., 2015; Schüz, et al., 2015).

Internal cues related to momentary affect but were not assessed for this study. Briefly however, in line with the protocol established by Wenzel, Kubiak, & Conner (2014), an abbreviated version of the Multidimensional Mood Questionnaire (MDMQ; Steyer, Schwenkmezger, Notz, & Eid, 1997) was employed to assess three dimensions of momentary affect : the *valence* scale (items: ‘good’ or ‘bad’), and two distinct arousal scales: *energetic arousal* (items: ‘awake’ or ‘tired’) and *tense arousal* (items: ‘nervous’ or ‘calm’). Participants moved a slider to indicate their response. Using a scale of 1 (*not at* all) to 5 (*extremely*); mean scores were calculated for each dimension.

Analytic Plan

The purpose of this study was to test whether the relationship between attentional bias and stimulus control is moderated by impulsivity. The dependent variable (stimulus control) was calculated following a procedure outlined in previous EMA research (e.g., Ferguson, Frandsen, Dunbar, & Shiffman, 2015). To allow for individual differences in response to food cues, stimulus control was assessed using within-subject logistic regression analyses. These within-subject models were designed to determine whether answers to the food availability items (described earlier) can distinguish between eating and non-eating assessments (random prompts). Using these models, individual area under the curve of the receiver-operating characteristic (AUC-ROC) scores; these scores were used as our estimate of the degree to which each participant’s eating was influenced by stimulus control. AUC-ROC scores were used because they are non-directional, and therefore allow for the discrimination of eating v. non-eating events irrespective of the direction of the association.

The ROC accuracy ratio is commonly used to gauge the accuracy of fitted binary logistic regression models (Sarkar & Midi, 2010). The ideal curve has an area of 1 (perfect prediction) while the worst case is around 0.5 (random chance). The area under the ROC curve provides an indication of the extent to which the model can differentiate between eating and non-eating instances (Sarkar & Midi, 2010).

Attentional bias (independent variable) was measured by the visual probe task. Following the score procedure outlined by Kemps and colleagues (2014), reaction Time (RT; in milliseconds) data were filtered by removing RTs for incorrect answers, for responses at or below 150ms and above 1,500ms, and those more than 3 *SDs* from that participant's mean. In accordance with previous research, attentional bias change scores were calculated per participant by subtracting the mean RT for probes replacing food images from the mean RT for probes replacing neutral (animal) images (Hou et al., 2011; Starzomska, 2017). Positive change scores suggested a food-related attentional bias, while negative scores indicated an attentional bias away from food.

Finally, impulsivity (the moderator variable) was measured by the Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995). Participant total scores; combining scores for all items, were used in moderation analysis to test whether impulsivity moderates the relationship between attentional bias and stimulus control.

Moderation analysis is prominent in basic and applied psychological research (e.g., Allom, Mullan, & Hagger, 2015; Uppal, 2017) and is useful for exploring the specific conditions under which two variables might be related (MacKinnon & Luecken, 2008). A moderator variable is one where the relationship between the independent and dependent variables changes in accordance with levels of the moderator (MacKinnon & Luecken, 2008). For this study, we explored the effect of impulsivity (moderator variable) on the strength and direction of the relationship between attentional bias (independent variable) and stimulus control (dependent variable). BMI was included in models as a covariate. Ordinarily, it is inadvisable to have multicollinearity (high correlations) between independent variables in moderation analysis because this may mask the specific contributions of each variable. High correlations among independent variables also encourage further issues such as larger standard errors for regression coefficients ("Moderation," n.d.). In this case, attentional bias and impulsivity were not highly correlated; $r = 0.05$, $p = .67$.

Results

Sample Characteristics

Seventy adults (24 males and 46 females) were recruited for this study. Participants' ages ranged from 18 to 71 (*M* = 30.8 years, *SD* = 11.7 years). Participants' BMIs ranged from 19 to 60.1 (*M* = 29.4, *SD* = 7.94). 25 (35.71%) participants were classified as healthy, 20 (28.57%) as overweight and 25 (35.71%) as obese. The majority of participants (64.29%) identified as Caucasian, with the second most common group being Asian (25.6%).

Each participant completed an average of 15.33 days of monitoring (*SD* = 1.55). Across participants, a total of 3,365 random prompts were completed. Additionally, participants self-reported a total of 1,372 drinks and 3,458 eating instances (2,137 meals and 1,331 snacks).

Moderation Analysis: Impulsivity on Attentional Bias and Stimulus Control

Means and score ranges for the three variables analysed are detailed in Table 1.

Table 1

Variable Means and Score Ranges

Variable	Mean (*SD)*	Minimum Score	Maximum Score
Stimulus control (food availability)	.64 (*.07*)	.53	.97
Attentional bias	5.95 (*19.23*)	-33.94	80.47
Impulsivity	64.38 (*8.32*)	49	81

Note. SD = standard deviation.

To test the research question of whether impulsivity moderates the relationship between attentional bias and stimulus control, we ran two models: BMI (as a covariate), attentional bias and impulsivity were entered in the first step, and the interaction term between attentional bias and impulsivity was entered in the second. No main effects and no moderation effect were found (Table 2). However, for Models 1 and 2, there was a trend towards the negative for both BMI (covariate) and attentional bias (independent variable) on stimulus control (dependant variable). Additionally, although no moderating effect was found, there was also a trend towards the negative for the attentional bias * impulsivity interaction on stimulus control.

Tests of simple slopes further illustrate the lack of interaction and provide an indication of the inverse trend between attentional bias and stimulus control at low (1 *SD* below the mean), average (the mean) and high (1 *SD* above the mean) levels of impulsivity (see Figure 4). At both average and high levels of impulsivity, the regression lines slope upwards, indicating that as levels of attentional bias decrease, levels of stimulus control increase. Additionally, the fact that the regression lines are effectively parallel indicates the absence of a moderating effect.

Finally, since some previous studies have reported that attentional bias varies by BMI, as an exploratory analysis**,** we tested whether the relationship between attentional bias and stimulus control was consistent across our three BMI ranges. Figure 5 shows the bivariate correlation between attentional bias and stimulus control among normal / healthy (BMI = 18.5-24.90; n = 25), overweight (BMI = 25-29.99; n = 20) and obese (BMI $\geq$30, n = 25) participants. As can be seen, the relationship between these variables did not vary by BMI, indicating that BMI is not a significant predictor of stimulus control.

Table 2

Hierarchical Regression Analysis for Variables Predicting Stimulus Control (Cued Eating)

	Model 1		Model 2	
Variable	*SE B*	*β*	*SE B*	*β*
Constant	0.47	.33	0.47	.38
BMI	0.02	-.01	0.02	-.01
Attentional Bias	0.12	-.22	0.12	-.20
Impulsivity	0.12	.08	0.12	.06
Attentional Bias * Impulsivity			0.14	-.17
R^2	.06		.08	
ΔR^2	.01		.02	
F(df) for change in R^2	1.28 (3, 66)		1.32 (4, 65)	

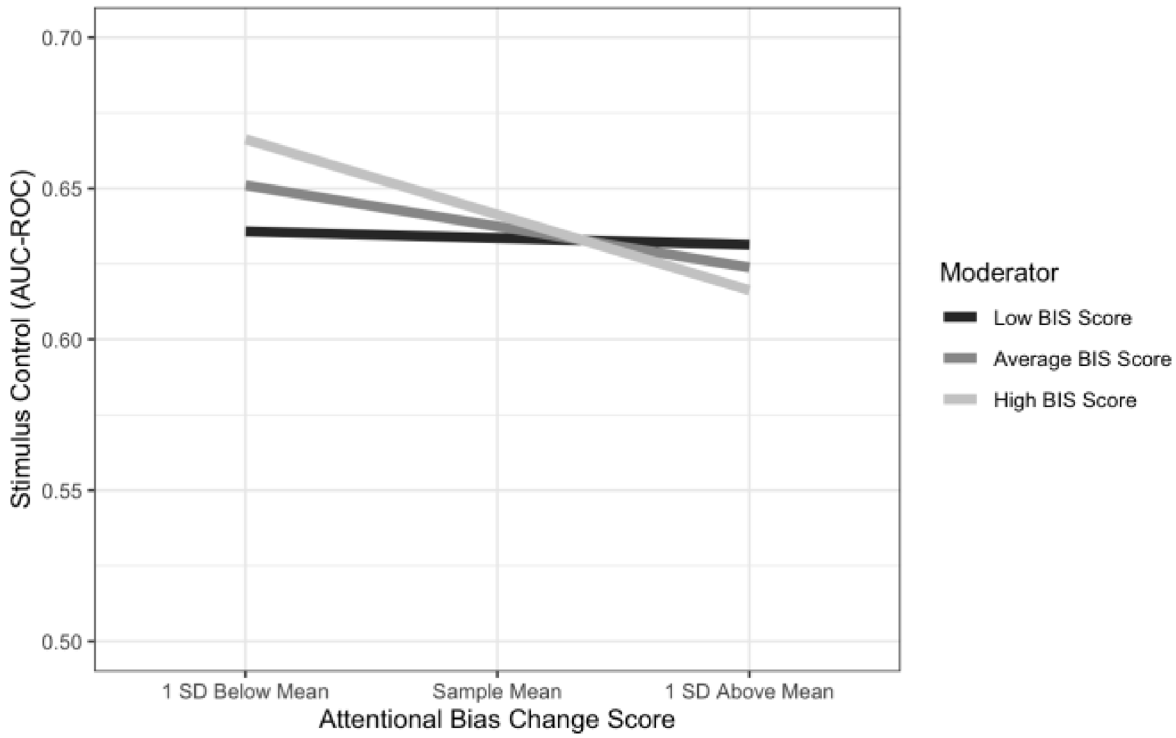

Figure 4. Simple slopes analysis: Relationship between stimulus control and attentional bias among participants with low, average and high impulsivity scores.

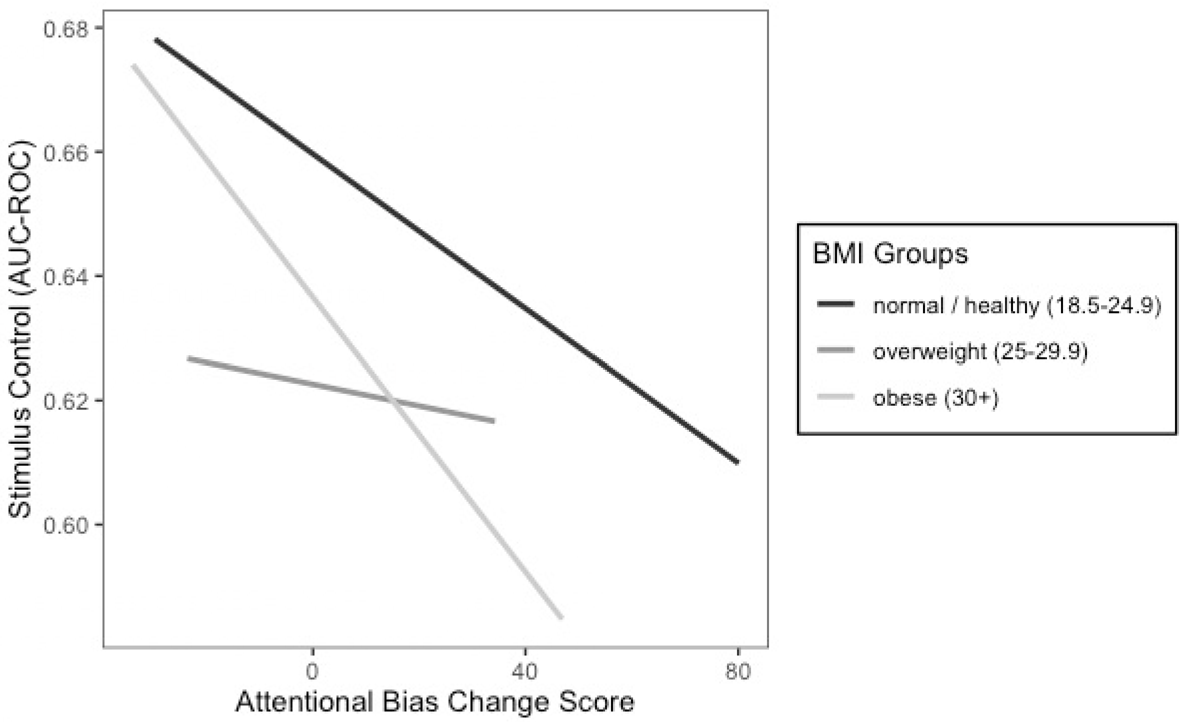

Figure 5. Correlation between attentional bias and stimulus control across BMI categories

Discussion

This study explored the effect of impulsivity as a moderator for the relationship between attentional bias and real-world stimulus control over an approximate 14-day monitoring period in a community sample. EMA methods were used to collect food reports and assessments of individual, situational and contextual cues to eating. This study does not support a linear relationship between heightened sensitivity to food cues within the environment and food intake. Nor does it support the role of personal restraint in influencing the strength of the relationship between attentional bias to food availability and subsequent food consumption. Contrary to the proposed hypothesis, there was no moderating effect of impulsivity on the relationship between attentional bias (to food availability) and stimulus control (cued eating). Furthermore, there was no significant positive correlation between attentional bias and stimulus control. If anything, the trend appeared to be towards the negative, so that greater attentional bias to food availability seemed to suggest less, not more, food consumed. Additional findings from this study did not support the research suggesting a linear relationship attentional bias and stimulus control across BMI ranges either; there was little difference in sensitivity to food availability between obese individuals and their healthy and overweight counterparts.

Attentional Bias and Stimulus Control

The findings from this study support those of a previous study conducted by this laboratory group (Franja et al., 2019). Attentional bias did not directly correlate with stimulus control. However, contrary to previous research, in this case the trend appeared towards the negative, so that higher attentional bias seemed to suggest lower stimulus control and vice versa. At first glance, these findings seem in contrast to a body of research positing that attentional bias to food cues within the environment drives consumption, (i.e., incentive-sensitization model; Hendrikse et al., 2015; Yokum et al., 2012). However, it might be that there are other mechanisms (e.g., trait eating behaviours; restrained, external or emotional) underpinning the relationship between food-related biases and food intake (Wilson, 2013). For example, it is possible to align the lack of correlation found in this study with the work of researchers such as Gearhardt, Treat, Hollingworth and Corbin (2012) who propose that the relationship between eating-related outcomes and visual attentional to food cues might be dependent on individual differences such as hunger and disordered or restricted eating. Individuals with disordered eating such as anorexia and bulimia nervosa will spend more time focusing on food-related words compared to neutral words on a visual search task (Smeets, Roefs, van Furth, & Jensen, 2008), while restricted eaters are more attentive to food words over non-food words Hollitt, Kemps, Tiggemann, Smeets, and Mills, 2010). Additionally, normal drive states such as momentary hunger have also been assessed as a precursor to food-related attentional bias. Some studies (e.g., Mogg, Bradley, Hyare, & Lee, 1998) have found a link between higher levels of hunger and a heightened attentional bias to food-related words within a dot probe task, suggesting that attentional bias may be susceptible to non-emotional motivational states and subsequent real-time variability.

Yet the present study attempted to control for the influence of motivational states such as hunger and disordered eating by ensuring that prior to commencement, participants were not dieting or demonstrating any abnormal eating patterns; as measured by the Eat-26. Additionally, before undergoing the visual probe task measuring attentional bias, participants were required to complete a modified version of the Grand Hunger Scale (Loeber et al., 2011) to prevent against the effect of hunger. It is possible that the afore-mentioned scales are not reliable measures, however both assessments demonstrate good validity, either formally; EAT-26: r=.79 (Mintz & O'Halloran, 2010) or by reputation; Hunger Scale (see Placanica, Faunce & Job, 2002; Stewart & Samoluk, 1997). As such, this research indicates the influence of other factors (e.g., differences in biases of attention, approach and subjective evaluation of food cues; Brignell, Griffiths, Bradley & Mogg, 2009) on the relationship between attentional bias and stimulus control.

The Role of Impulsivity

It was hypothesised that impulsivity would moderate the relationship between attentional bias and stimulus control. However, the findings of this study were not supportive of this premise. There was no moderating effect of impulsivity, and no interaction between attentional bias and impulsivity. Indeed, such was the nature of the findings, that perhaps somewhat counter-intuitively, it appeared that high levels of impulsivity paired with higher levels of attentional bias, did not equate to greater consumption in response to stimulus control. This does not correspond with the literature (e.g., Lattimore & Mead, 2012; Meule & Platte, 2016) positing that heightened attentional bias to food cues and greater impulsivity interactively predict [over]eating. Nor does it lend support for the theoretical paradigm of dual-process models, whereby automatic processes involving cognitive biases, e.g., attentional bias, elicit the tendency to move towards certain food-related cues within the environment. Depending on the strength of the system, automatic processes are typically regulated by controlled processes, e.g., inhibitory control, which censor the behavioural outcome (Kakoschke, Kemps, & Tiggeman, 2017).

When considering these findings, it may be beneficial to review the measurement of impulsivity. In this study, impulsivity was assessed using the BIS-11. As discussed, this is a well-validated tool (Stanford et al., 2009), used in multiple studies (e.g., Buckholtz et al., 2010; Sanchez-Roige et al., 2019). However, there is some emerging evidence to indicate an instability amongst the factors within the scale. For example, Vasconcelos, Malloy-Diniz and Correa (2012) conducted a review of the psychometric properties of the scale and found that while the BIS-11 had reasonable reliability and validity, there was an instability with regards to the three factors (Motor, Attentional and Non-Planning Impulsivity) it proports to assess.

Similarly, research by Stevens, Blanchard and Littlefield (2018) posited that, while one of the reputed strengths of the BIS-11 is its recognition of impulsivity as a multi-faceted (cf. unidimensional) construct, it consistently demonstrates sub-optimal fits for the six and second-order factor models (Reise, Moore, Sabb, Brown, & London, 2013) in comparison to the unidimensional model.

Although the general consensus within the literature is that impulsivity is a trait (cf. state) that is linked to [over]eating and possible weight gain, little is known about the neural mechanisms underpinning the relationship. Given that impulsivity is a multi-faceted construct, it may even be that the impulsivity subtypes; themselves ill-defined within the literature (see Caswell, Bond, Duka, Morgan, 2015), have different neurobiological substrates (Michaelides et al., 2013) underpinning responses to food choices (van der Laan, Barendse, Viergever, & Smeets 2016).

Furthermore, it is possible that using a single measure of impulsivity does not allow for the wide array of processes and subtypes eliciting impulsive behaviour (van der Laan et al., 2016). The neural independence of impulsivity subtypes may provide some explanation for their well-documented lack of correlation, and perhaps elucidate why various self-report and behavioural measures seem to assess different aspects of impulsivity (Meule, 2013). However, the literature associating the various factors of impulsivity with impulsive food consumption contrasts greatly. For example, some initial research proposed a link between attentional impulsivity and an increased likelihood of calorie-dense foods drawing attention and driving eating behaviours (Hou et al., 2011; Nolan, 2012). However, subsequent studies (Meule & Platte, 2016; Nederkoorn et al., 2010) revealed an interaction specifically between motor impulsivity (i.e., acting without thinking) and an attentional bias toward high calorie foods. Within these studies, such an interaction was prospectively predictive of subsequent weight gain, but only with regard to self-reported motor impulsivity, and not attentional and non-planning impulsivity. The contradictory nature of these findings, combined with that of the present study serve to highlight the knowledge gap with regard to the causal factors pertaining to the relationship between impulsivity, attentional bias and eating patterns. Therefore, future studies are necessary to address which sub traits of impulsivity are related to cue-responsive [over]eating and to explore potential moderators and mediators for such a relationship. It might, for example, be possible that the relationship between certain facets of impulsivity and food consumption are mediated by external eating (i.e., eating in response to external cues; Kakoschke, 2015b) and BMI; which, for obese individuals, has been associated with deficits in cognitive performance and discrepancies between intended and actual food intake (van den Akker, Stewart, Antoniou, Palmberg & Jansen, 2014).

The Role of BMI

Although not a direct focus of this study, some interesting findings emerged with regards to the relationship between BMI and the three variables under consideration; attentional bias, impulsivity and stimulus control. It was found that BMI was not a significant covariant for stimulus control. This is perhaps counter-intuitive and appears to contradict the bulk of research (e.g., Calitri et al., 2010; Hendrikse et al., 2015) which posits that cognitive biases towards food are predictive of excess consumption and subsequent weight gain, and that individuals with obesity typically demonstrate enhanced reactivity to food stimuli (Yokum et al., 2012). In this study, obese participants demonstrated no real difference in attentional bias to food cues than their normal and overweight counterparts. One possible reason for this is that people with obesity do not place added significance to food-related information compared to lower BMI groups. It may even be that of the three BMI categories, overweight (*cf.* obese) individuals demonstrate the greatest degree of motivation for food and food-predicting cues. The findings of this study are similar to those of a study by Lehner, Balsters, Bürgler, Hare and Wedneroth (2017). In this case, the researchers used eye-tracking during Pavlovian conditioning to assess the participant's learned response as an indication of the salience of the anticipated reward. Lehner et al. proposed the findings could be explained in terms of incentive-sensitisation theory (Robinson & Berridge, 2001). The incentive-sensitisation model posits an attentional bias toward reward[food]-specific cues, most demonstrable in overweight individuals. However, it may be that once obese status is attained, reward-circuitry functioning returns to ordinary levels.

Another explanation might be that BMI is not directly related to cue-responsiveness. It may be that BMI is the result, rather than an indication of, cued [over]eating. Further to this, it may be that individual differences (e.g., neural response pathway activation; McGeown & Davis, 2018, social influences; Leahey, LaRose, Fava, & Wing, 2010, or restrained v. non-restrained eating approaches; Werthmann et al., 2013) drive eating, irrespective of BMI. This idea warrants further investigation in future research exploring the relationship between food-cue responsiveness and eating (Elliston, 2015).

Strengths and Limitations

A key strength of this study was that it was (to our knowledge) the first to employ EMA technology to explore the impact of individual levels of impulsivity and attentional bias on real-world eating patterns. EMA technology is advantageous to either laboratory-based or traditional hardcopy diary assessments of food intake because it captures the flow of mood, behaviour and events experienced by the participants before they eat (Shiffman et al., 2008). This is achieved through the momentary (real-time) collection of data relating to dietary intake as well as the repeated sampling of contextual details pertaining to the variability of the individual's mood, situation and current activity. Finally, EMA assessments manage the issues of biased or limited recall and selective reporting of foods consumed which are common to traditional studies on nutritional intake (Lissner, 2002). In this way, EMA technology facilitates a more ecologically-valid study and better generalizability of the participant's lived experience of cue responsiveness and eating (Grenard et al., 2013).

This study was, however, not without some limitations which may have influenced the outcome. It is possible that the lack of support for the hypothesis resulted from an issue with some aspect of the methodology, theoretic paradigms and / or means of assessment utilised. Of the three variables; stimulus control, impulsivity and attentional bias, the latter appears the most elusive within the literature. As previously discussed, both stimulus control and impulsivity were assessed using ecologically valid and reliable methodology, however, while the general consensus is that higher attentional bias(es) to food cues may trigger craving, resulting in (over)eating, variability in stimuli and paradigm parameters between studies have made it difficult to assess under what conditions such biases may be elicited (Freijy et al., 2014). We employed the visual probe task to measure attentional bias; typically considered the 'gold standard' of measurement because it allows for the differentiation of attention towards or away from a particular type of stimuli (Smeets et al., 2008). Yet even here, the evidence for the presence of an effect (of certain groups being more susceptible to attentional bias over others) remains somewhat contentious (Smeets et al.). For instance, some studies have found no difference in attentional allocation to probe food cues between individuals categorised by level of dietary restraint (Werthmann et al., 2013) or BMI (Nijs et al., 2010a). Additionally, it may also be possible that, similar to impulsivity, attentional bias is multi-dimensional. This would mean that individuals do not demonstrate a uniform responsiveness to all food-related cues, rather they are hyper-sensitive to some over others (Schüz et al., 2015).

For this study, we selected the image version of the dot probe task which, although not validated within the literature (Smeets et al., 2008), intuitively seems more ecologically-valid than words because of the closer approximation to real-world stimuli. It was for this reason that food-availability was selected as a proxy for stimulus control. The idea being that it maps most closely (*cf.* time, mood, social influence) to the immediacy of the imagery of the visual probe task. However, we did not distinguish between individual preferences for food-related cues, e.g., smell, location, presence of others, or even between the caloric significance of the food images used. For example, some studies (Kemps & Tiggeman, 2009; Nijs et al., 2010) have reported an attentional bias towards high-calorie food cues over low calorie. This study may have benefitted from testing whether participants responded differently to types of food cues, and perhaps incorporating this into the methodology. It is possible that in using only one stimulus, important information (e.g., individual preferences of certain food cues over others) was overlooked (smeets et al.). Future research in this area could further explore this distinction.

Finally, the sample size (*N* = 70) may have been restrictive. As this was, largely, an exploratory analysis, no power analysis was conducted prior to commencement. However, this is the second study in which the anticipated correlation between attentional bias and stimulus control has not been established. There is, therefore, no reason to infer that, with a larger sample size, anything but a trend towards the non-significant would have been realised. Furthermore, intensive and longitudinal EMA-based studies such as this are economical, meaning that the number of participants would have been sufficient to gather reliable estimates of parameters (Schüz et al., 2015). This was because the intensive design of the study in terms of how the data was collected (i.e., event-based monitoring; record of actual food consumed, v. time-based monitoring; random-prompt assessments), resulted in an increased number of observations obtained per individual, relevant to the context of eating events (Shiffman et al., 2008).

Implications and Conclusions

This study has highlighted the complexity of the relationship between attentional bias and stimulus control and the mechanisms underpinning it. Despite the body of research to the contrary, no evidence was found for a moderating effect of impulsivity on cue responsiveness and real-world eating. It may even have been the case, that in adopting the innovative approach of employing EMA technology to explore the impact of the environment on eating behaviours and finding no relationship, we have inadvertently demonstrated the previously unexplored real-time variability and multi-dimensionality of attentional bias to food cues. In addition to levels of personal restraint, it is likely that other factors such as susceptibility to the influence of social norms, quantity of food consumed at a time and differentiation in activation of neural response pathways contribute to eating behaviours.

This research has relevant implications for understanding obesity and overweight and demonstrates the gaps in literature with regards to developing sustainable weight loss interventions. Furthermore, this study serves to illustrate the many probable factors driving dietary intake. The results suggest that individuals demonstrating higher levels of attentional bias to food availability and impulsivity do not necessarily consume more than those for whom the opposite is true. Additionally, these findings cannot be explained by BMI category. This suggests that although attentional bias, stimulus control, impulsivity and perhaps BMI, are most likely related, the relationship is not necessarily linear and difficult to interpret (van den Akker et al., 2014). Future research into behavioural interventions for obesity should, therefore, focus on a) further exploration of the reasons why people eat, b) standardised methods for measuring attentional bias, and c) the real-time variability of, and individual differences in, cognitive biases towards food.

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Table of Appendices

Appendix A

Ethics Approval Letter

UNIVERSITY of TASMANIA

03 May 2019

AssocProf Stuart Ferguson
C/- University of Tasmania

Sent via email

Dear AssocProf Ferguson

REF NO: H0018038
TITLE: Cognitive and environmental predictors of food choices

We are pleased to advise that acting on a mandate from the Tasmania Social Sciences HREC, the Chair of the committee considered and approved the above project on 03 May 2019.

Please ensure that all investigators involved with this project have cited the approved versions of the documents listed within this letter and use only these versions in conducting this research project.

This approval constitutes ethical clearance by the Tasmania Social Sciences HREC. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approvals of other bodies or authorities are required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

In accordance with the National Statement on Ethical Conduct in Human Research, it is the responsibility of institutions and researchers to be aware of both general and specific legal requirements, wherever relevant. If researchers are uncertain they should seek legal advice to confirm that their proposed research is in compliant with the relevant laws. University of Tasmania researchers may seek legal advice from Legal Services at the University.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on the Ethical Conduct in Human Research* (NHMRC 2007 updated 2018).

Therefore, the Chief Investigator's responsibility is to ensure that:

(1) All investigators are aware of the terms of approval, and that the research is conducted in compliance with the HREC approved protocol or project description.

(2) Modifications to the protocol do not proceed until **approval** is obtained in writing from the HREC. This includes, but is not limited to, amendments that:

(i) are proposed or undertaken in order to eliminate immediate risks to participants;

Human Research Ethics Committee (Tasmania) Network
Research Ethics and Integrity Unit
Office of Research Services
Private Bag 1
Hobart Tasmania
7001
Australia
T +61 3 6226 6254
E ss.ethics@utas.edu.au
ABN 30 764 374 782 /CRICOS 00586B

Appendix B

Information Sheet and Consent Form

Private Bag 34 Hobart
Tasmania 7001 Australia
Phone: (03) 6226 4295
Email: Stuart.Ferguson@utas.edu.au

SCHOOL OF MEDICINE, MEDICINE

UNIVERSITY OF TASMANIA

PARTICIPANT INFORMATION SHEET

Cognitive and environmental predictors of food choices

1. Invitation

You are invited to participate in a research study investigating the drivers of eating. The study is being conducted by Katherine Elliston, Stefania Franja, Anna McCrae, Ashlee Withers, Dr Helena Chui and Associate Professor Stuart Ferguson from the College of Health & Medicine at the University of Tasmania. This research is being conducted in partial fulfilment of a PhD degree by Katherine Elliston and Stefania Franja, and in partial fulfilment of an Honours degree by Anna McCrae and Ashlee Withers.

2. What is the purpose of this study?

This study aims to investigate the influence of cognitive, mood and environmental factors on the consumption of food and drink. Data will be gathered on the individual (e.g., craving, hunger, mood), as well as social and situational (e.g., location, company) antecedents of consumption, as well as how people feel after eating/drinking. These results will be matched to cognitive measures taken in laboratory. Results from this research have the potential to influence the development of more efficacious treatments to support people beginning and maintaining a healthy diet.

3. Why have I been invited to participate in this study?

You are eligible to participate in this study because you are over 18, have a BMI ≥18.5, and interested in contributing to research about eating patterns.

4. What will I be asked to do?

If you choose to participate in this study, you will be asked to take part in 14 days of recording food and drink intake (explained below) as well as complete two (2) computer-based cognitive tasks in our laboratory.

While in the study, you will be recording your eating/drinking patterns and your feelings and experiences as you go about your daily life. To do this, we will supply you with a specially-programmed electronic diary. You will need to return this diary at the end of the study.

You will need to carry the diary with you wherever you go at all days of the study and record and photograph each time you consume any food or drink. Some of these recordings will be followed up by a brief assessment consisting of questions asking about the social, emotional, and environmental predictors relating to where you had your food or drink. You will also be asked to complete 4-5 assessments at random time points during the day. Each assessment will only take about 1 minute to complete. During these assessments, the diary will automatically record the time and your GPS location. We will provide you with training on how to use the diary and will happily answer any questions you might have regarding participating in this study.

Participating in this study will require you to visit the University of Tasmania three (3) times for study visits. Visit 1 will be the initial visit to enrol in the study (approximately 60 minutes), Visits 2 and 3 will be shorter (approximately 10-30 minute) visits; Visit 2 will be around day three of participating, and Visit 3 will be scheduled on approximately day 14 of the study. During the Visit 1, you will receive training on how to use the diary and you will be asked to complete some baseline questionnaires to help us gather background information on yourself and your current and previous eating behaviour. During Visit 2, the data will be downloaded from your diary and any additional questions you might have will be answered; you will also be asked to complete some computer-based cognitive tasks. During visit 3, after approximately 14 days of recording food and drink, you will return the study diary, complete additional computer-based cognitive tasks and receive some debriefing regarding your experiences during the study. Upon return of the diary, you will be reimbursed $60 for your time and contribution to the research.

All information will be treated in a highly confidential manner; your name or any identifying information will not be used in any publication arising from this research including research thesis. All data will be analysed without identifying information so no individual participants can be identified.

5. Are there any possible benefits from participation in this study?

It is possible that the monitoring technology used in this study will help you learn more about your individual eating and/or drinking behaviour. Furthermore, the information we gather may be beneficial for other people by contributing to the development of future dietary management interventions.

6. Are there any possible risks from participation in this study?

There are no specific risks anticipated with participation in this study.

7. What if I change my mind during or after the study?

It is important that you understand that your involvement in this project is voluntary and confidential, and that you are free to withdraw from this project at any stage and any of your data that has been collected may be removed any time prior to commencement of data analysis. Your withdrawal will not affect your relationship with UTAS in any way.

8. How will the results of the study be published?

When the study has been completed, the main outcomes will be published on the University of Tasmania's website and in scientific journal articles. Results from this study may be included in theses by Katherine Elliston, Stefania Franja, Anna McCrae, and Ashlee Withers.

We will also be promoting our findings on our lab Facebook page: The Behavioural and Situational Rsearch Group (BSRG).

9. What will happen to the data when the study is over?

The research data will be kept in a locked file cabinet (hard copies) at the School of Medicine, and all electronic data will be kept on a password-protected computers. In accordance with National Ethics Guidelines, hard copy data will be kept for **at least** five (5) years before being destroyed. Electronic data will be stored indefinitely and made available in de-identifiable format to other researchers if requested.

10. What if I have questions about this study?

If you would like to discuss any aspect of this study please feel free to contact our team on (03) 6226 1093. We are happy to discuss any aspect of the research with you. You are welcome to contact us to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 6254 or email ss.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H0018038.

Thank you for taking the time to consider this study.

If you wish to take part in it, please sign the attached consent form.

This information sheet is for you to keep.

Private Bag 30 Hobart
Tasmania 7001 Australia
Phone (03) 6226 4295
Email: Stuart.Ferguson@utas.edu.au

SCHOOL OF MEDICINE, PSYCHOLOGY

UTAS

UNIVERSITY OF TASMANIA

CONSENT FORM

Cognitive and environmental predictors of food choices

1. I acknowledge that the nature, purpose and contemplated effects of the project so far as it affects me, have been fully explained to my satisfaction by the study staff member and my consent is given voluntarily.

2. The details of the research have also been explained to me, including the anticipated length of time it will take, the frequency with which the assessments will be performed. I understand that my participation involves:

    - Fourteen (14) days of monitoring. Specifically, while in the study, I will be asked to monitor my eating and drinking behaviour and associated questions using a specially-programmed diary. I understand that my participation involves carrying this diary with me at all times for the duration of the 14-day study.
    - Three study visits to the University of Tasmania campus, each of which will take between 10 and 60 minutes to complete;
    - The completion of questionnaires assessing demographics factors, current diet, mood, hunger and personality traits.
    - Completion of computer-based cognitive tasks
    - Being reimbursed $60 upon completion of the third visit and return of diary to compensate for my time.

3. I understand that there are no risks anticipated from my involvement in this research.

4. I understand that my involvement in the project is voluntary and confidential and will not affect my relationship with UTAS in any way. I also understand that I am free to withdraw from the project at any stage and any of my data that has been collected may be removed any time prior to commencement of data analysis. My withdrawal will not affect my relationship with UTAS in any way.

5. I understand that I will be given a signed copy of the participant information sheet and consent form. I am not giving up my legal rights by signing this consent form.

6. I understand that research data gathered from me may be published, provided that I cannot be identified as a person.

7. I understand that the researchers will maintain my identity as confidential and that any information I supply to the researchers will be used only for the purposes of this research.

8. I understand that the research will be conducted in accordance with the latest versions of the *National Statement on Ethical Conduct in Human Research 2018* and applicable privacy laws.

9. I understand that the hard copy data collected in the study will be stored by the University of Tasmania for a period of **at least** five years before being destroyed. I understand that electronic data will be stored indefinitely and made available in de-identifiable format to other researchers if requested.

10. I understand that the data collected in the study may be included in theses by Katherine Elliston, Stefania Franja, Anna McCrae, and Ashlee Withers

11. Any questions that I have asked have been answered to my satisfaction.

Name of participant:

Signature of participant:

Date:

I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Name of investigator:

Signature of investigator:

Date:

Private Bag 30 Hobart
Tasmania 7001 Australia
Phone (03) 6226 4295
Email: Stuart.Ferguson@utas.edu.au

SCHOOL OF MEDICINE, PSYCHOLOGY

UTAS

UNIVERSITY OF TASMANIA

CONSENT FORM

Cognitive and environmental predictors of food choices

1. Additionally, I consent to have my name and email address kept on file for the purpose of being contacted for future eating studies conducted by the research team.

If you approve, please tick the following indicating your agreement with the above statement:

I agree

Name of participant:

Signature of participant:

Date:

Appendix C

Flyer advertisement

Interested in participating in a study about eating?

The University of Tasmania is looking for individuals with a BMI ≥ 18.5 for a study on everyday eating and drinking

All participants will receive $60 on completion of the study

Visit our website for information and contact details:

http:tinyurl.com/foodchoices4

Or call us on (03) 6226 8362

Ethics approval number H0018038

UNIVERSITY *of* TASMANIA | MENZIES Institute for Medical Research

Appendix D

EMA Questions

```
<?xml version="1.0" encoding="UTF-8"?>

<emastudy parserVersion="20140605" menuHeading="Choices"
id="foodchoices4"><properties>

<!-- Set on setup -->

<property type="number" adminCanSet="1" prependToSurveyLogs="true"
forceSetValue="true" name="subject">999</property><property type="date"
adminCanSet="1" prependToSurveyLogs="true" forceSetValue="true"
name="startDate"/><property type="boolean" adminCanSet="1" name="isBedtime"
persistent="true">false</property><property type="integer" adminCanSet="1"
name="wakeAlarmTime" persistent="true">0800</property>

<!-- Temporary variables -->

<property adminCanSet="0" name="header" persistent="false"/><property
adminCanSet="0" name="fullAssessment" persistent="false"/><property adminCanSet="0"
name="targetdrink" persistent="false"/><property adminCanSet="0"
name="showWakeMessage" persistent="false"/><property adminCanSet="0"
name="isAlone" persistent="false"/><property adminCanSet="1"
name="FoodFullAssessmentsToday" persistent="true"/><property adminCanSet="1"
name="DrinkFullAssessmentsToday" persistent="true"/><property adminCanSet="1"
name="assessment_probability"
persistent="true"/></properties><connection><details><detail name="Study"><parameter
name="value">foodchoices4</parameter></detail><detail name="Participant
ID"><parameter type="property" name="value"
property="subject"/></detail></details><compliance><column type="date"
heading="date"/><column type="eventHappened" heading="Evening Report"
log="completed" logItemId="evening_report"/><column type="eventCount"
heading="Logged food" log="started" logItemId="food_action"/><column
type="eventCount" heading="Logged drinks" log="started"
logItemId="drink_action"/><column type="eventCount" heading="RP Completed"
log="completed" logItemId="random_prompt_action"/><column type="eventCount"
heading="RP Issued" log="Prompt fired" logItemId="random_prompt_action"/><column
type="promptCompliance" heading="RP Compliance" surveyID="random_prompt"
promptActionID="random_prompt_action"/><column type="eventCount"
heading="Suspends" log="Phone suspended"/><column type="suspendTime"
heading="Suspend time"/></compliance></connection><initialisation>
</initialisation><scheduledtasks>

<!-- If it's after 12pm and before 8pm and it's still set to bedtime, turn it off -->

<scheduled id="disable_bedtime_mode" time="1200"><constraint type="timeSinceEvent"
log="db" minutes="10" detail="initialised"/><constraint type="timeWindow"
endTime="2000"><parameter type="property" name="startTime"
property="wakeAlarmTime"/></constraint><constraint type="propertyIsTrue"
property="isBedtime"/><logic type="setProperty" property="isBedtime"
value="false"/><logic type="log" log="bedtime ended"/></scheduled>
```

<!-- Reset counts every day at 4.30am or the first possible time after then (e.g., when the phone is turned on in the morning) -->

<scheduled id="**start_daily_counts**" time="**0400**"><logic type="**setProperty**" property="**FoodFullAssessmentsToday**" value="**0**"/><logic type="**setProperty**" property="**DrinkFullAssessmentsToday**" value="**0**"/><logic type="**log**" log="**food assessment count reset**"/><logic type="**log**" log="**drink assessment count reset**"/></scheduled></scheduledtasks><notifications><notification text="**(ASLEEP)**"><constraint type="**propertyIsTrue**" property="**isBedtime**"/></notification></notifications><actions>

<menu><action id="**food_action**" name="**Food**"><parameter name="**confirm**">true</parameter><parameter name="**confirmMessage**">Log Food?</parameter><survey id="**food_survey**" allowBack="**false**"><question id="**photo**" type="**radiobutton**" text="**Can you take a photo of what you are eating?**"><answer text="**Yes**"><camera id="**food**"/></answer><answer text="**No**"/></question><question id="**foodtyp**" type="**radiobutton**" text="**Type of meal?**" allowBack="**false**"><answer text="**Main meal**"><question id="**fooddr**" type="**radiobutton**" text="**Consuming a drink with your meal?**"><answer text="**Yes**"><question id="**drink_type**" type="**checkbox**" text="**What type of drink?**"><answer text="**Coffee/Tea**"/><answer text="**Milk**"/><answer text="**Alcohol**"><question id="**alc_standard**" type="**spinner**" text="**ABOUT ALCOHOLIC DRINK: How many standard drinks?**" maxValue="**10**" minValue="**1**"/><question id="**alc_drunk**" type="**slider**" text="**FEELING: Intoxicated/drunk?**" maxLabel="**Yes!!**" minLabel="**No!!**"/></answer><answer text="**Energy drink**"/><answer text="**Soft drink**"/><answer text="**Juice**"/><answer text="**Water**"/><answer text="**Other**"/></question></answer><answer text="**No**"/></question></answer><answer text="**Other**"><question id="**snack_type**" type="**checkbox**" text="**What type of food?**"><answer text="**Confectionery**"/><answer text="**Potato chips/crackers**"/><answer text="**Dried fruit/coated nuts/bars**"/><answer text="**Fruit/vegetables/nuts**"/><answer text="**Dairy products**"/><answer text="**Bakery items**"/><answer text="**Fast food**"/><answer text="**Other**"/></question></answer></question><logic type="**setProperty**" property="**fullAssessment**" value="**false**"/><logic type="**setProperty**" property="**fullAssessment**" value="**true**"><constraint type="**probability**"><parameter name="**numerator**" value="**60**"/><parameter name="**denominator**" value="**100**"/></constraint></logic><group><constraint type="**propertyIsTrue**" property="**fullAssessment**"/><constraint type="**notSuspended**"/><constraint type="**propertyIsFalse**" property="**isBedtime**"/>

<!--If you have sampled within the last 15mins, don't bother doing it again -->

<!--<constraint type="timeSinceEvent" log="daily_food_assessment_tally" minutes="15" negate="true"/> -->

<logic type="**incrementProperty**" property="**FoodFullAssessmentsToday**" amount="**1**"/><logic type="**log**" log="**daily_food_assessment_tally**"><parameter type="**property**" name="**detail**" property="**FoodFullAssessmentsToday**"/></logic><message text="**Remaining items refer to the situation where you first decided to eat**"/><logic type="**setProperty**"

property="**header**" value="**FEELING:** "/><link taskid="**feeling**"/><logic type="**setProperty**" property="**header**" value="**WHEN YOU DECIDED TO EAT:** "/><link taskid="**location_regulation_social_activities_consumption**"/><link taskid="**current_craving**"/><link taskid="**advertisements**"/></group><message text="**Last chance to go back. Push arrow to complete**"/></survey><message text="**Thank you, good bye.**"/></action><action id="**drink_action**" name="**Drink**"><parameter name="**confirm**">true</parameter><parameter name="**confirmMessage**">Log Drink?</parameter><survey id="**drink_survey**" allowBack="**false**"><logic type="**setProperty**" property="**fullAssessment**" value="**false**"/><logic type="**setProperty**" property="**targetdrink**" value="**false**"/>

<!--Always ask this first question-->

<question id="**drink_type**" type="**checkbox**" text="**What type of drink?**"><answer text="**Coffee / Tea**"/><answer text="**Milk**"/><answer text="**Alcohol**"><question id="**alc_standard**" type="**spinner**" text="**ABOUT ALCOHOLIC DRINK: How many standard drinks?**" maxValue="**10**" minValue="**1**"/><question id="**alc_drunk**" type="**slider**" text="**FEELING: Intoxicated/drunk?**" maxLabel="**Yes!!**" minLabel="**No!!**"/><logic type="**setProperty**" property="**targetdrink**" value="**true**"/></answer><answer text="**Energy Drink**"><logic type="**setProperty**" property="**targetdrink**" value="**true**"/></answer><answer text="**Soft drink**"><logic type="**setProperty**" property="**targetdrink**" value="**true**"/></answer><answer text="**Juice**"/><answer text="**Water**"/><answer text="**Other**"/></question>

<!--NB: This only runs if we care about the drink type -->

<group><constraint type="**propertyIsTrue**" property="**targetdrink**"/>

<!--Choose option 1 or 2 for sampling ... and number 2 is clearly broken -->

<!--likely because GT is NOT an evaluate option. See email from aidan about negate option setting -->

<logic type="**setProperty**" property="**fullAssessment**" value="**true**"><constraint type="**probability**"><parameter name="**numerator**" value="**60**"/><parameter name="**denominator**" value="**100**"/></constraint></logic>

<!-- <logic type="setProperty" property="assessment_probability" value="60"> <constraint type="evaluate" operation="lt"> <parameter name="operandA">3</parameter> <parameter name="operandB" type="property" property="DrinkFullAssessmentsToday"/> </constraint> </logic> <logic type="setProperty" property="assessment_probability" value="20"> <constraint type="evaluate" operation="gt"> <parameter name="operandA">2</parameter> <parameter name="operandB" type="property" property="DrinkFullAssessmentsToday"/> </constraint> </logic> <logic type="setProperty" property="fullAssessment" value="true"> <constraint type="probability"> <parameter name="numerator" type="property" property="assessment_probability"/> <parameter name="denominator" value="100"/> </constraint> </logic> -->

</group><group><constraint type="**propertyIsTrue**" property="**fullAssessment**"/><constraint type="**notSuspended**"/><constraint type="**propertyIsFalse**" property="**isBedtime**"/>

<!--If you have sampled within the last 15mins, don't bother doing it again -->

<!--<constraint type="timeSinceEvent" log="started" minutes="15" logItemId="drink_survey" negate="true"/> -->

<!--<constraint type="timeSinceEvent" log="daily_drink_assessment_tally" minutes="15" logItemType="log" negate="true"/> -->

<logic type="incrementProperty" property="DrinkFullAssessmentsToday" amount="1"/><logic type="log" log="daily_drink_assessment_tally"><parameter type="property" name="detail" property="DrinkFullAssessmentsToday"/></logic><message text="Remaining items refer to the situation where you first decided to drink"/><logic type="setProperty" property="header" value="FEELING: "/><link taskid="feeling"/><logic type="setProperty" property="header" value="WHEN YOU DECIDED TO DRINK: "/><link taskid="location_regulation_social_activities_consumption"/><link taskid="current_craving"/><link taskid="advertisements"/><message text="Last chance to go back. Push arrow to complete"/></group></survey><message text="Thank you, good bye."/></action><action id="edit_alarm" name="Check/Edit Alarm"><constraint type="propertyIsTrue" property="isBedtime"/><question id="change_alarm_time" type="radiobutton"><parameter type="concatenate" name="text"><parameter>The wake alarm is set for </parameter><parameter type="formattedTime"><parameter type="property" name="time" property="wakeAlarmTime"/></parameter><parameter>. Change alarm time?</parameter></parameter><answer text="Yes"><link taskid="set_alarm_time"/></answer><answer text="No"/></question><message text="Please remember to charge device overnight. Thank you, good night."/></action><action id="wake_report_action" name="Wake"><constraint type="propertyIsTrue" property="isBedtime"/>

<!-- Available between 4.30am and 12pm -->

<constraint type="timeWindow"><parameter name="startTime">430</parameter><parameter name="endTime">1200</parameter></constraint><link taskid="end_bedtime"/><link taskid="wake_report"/><message text="Thank you, good bye."/></action><action id="evening_report_action" name="Evening Report"><parameter name="confirm">true</parameter><parameter name="confirmMessage">Enter Evening Report?</parameter>

<!-- Available between 7pm and midnight -->

<constraint type="timeWindow" endTime="2359" startTime="1900"/>

<!-- ...only if if has not yet been done -->

<constraint type="timeSinceEvent" log="completed" logItemId="evening_report" hours="12"/><survey id="evening_report"><message text="The following questions refer to events occurring since the last morning report"/><question id="num_meals" type="spinner" text="How many meals consumed today?" maxValue="10" minValue="0"/><question id="num_snacks" type="spinner" text="How many snacks consumed today?" maxValue="10" minValue="0"/><question id="num_drinks"

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type="spinner" text="How many drinks consumed today?" maxValue="10"
minValue="0"/><question id="craving_any" type="radiobutton" text="TODAY: Found
yourself craving food at any stage?"><answer text="Yes"><question id="craving"
type="slider" text="Craving intense?" maxLabel="Yes!!" minLabel="No!!"/><question
id="craving_what" type="checkbox" text="What food were you craving?"><answer
text="Confectionery"/><answer text="Potato chips/crackers"/><answer text="Dried
fruit/coated nuts/bars"/><answer text="Fruit/vegetables/nuts"/><answer text="Dairy
products"/><answer text="Bakery items"/><answer text="Fast food"/><answer
text="Other"/></question></answer><answer text="No"/></question><logic
type="setProperty" property="header" value="OVERALL FEELING TODAY: "/><link
taskid="feeling"/><question id="confess_meal" type="spinner" text="Meals consumed but
not yet entered?" maxValue="10" minValue="0"/><question id="confess_snack"
type="spinner" text="Snacks consumed but not yet entered?" maxValue="10"
minValue="0"/><question id="confess_drink" type="spinner" text="Drinks consumed but
not yet entered?" maxValue="10" minValue="0"/><question id="exercse_any"
type="radiobutton" text="Exercised today?"><answer text="Yes"><question
id="exercise_time" type="radiobutton" text="How long did you exercise for?"><answer
text="0-10 mins"/><answer text="10-30 mins"/><answer text="30 mins-1 hour"/><answer
text="1-2 hours"/><answer text="2-3 hours"/><answer text=">3
hours"/></question></answer><answer text="No"/></question><message text="Last
chance to go back. Push arrow to complete"/></survey><message text="Thank you, good
bye."/></action><action id="bedtime_action" name="Bedtime"><parameter
name="confirm">true</parameter><parameter name="confirmMessage">Enter Bedtime
Report?</parameter>

<!-- Available between 7pm and 4.30am -->

<constraint type="group" selection="or"><constraint type="timeWindow"
endTime="2359" startTime="2000"/><constraint type="timeWindow" endTime="430"
startTime="0"/></constraint>

<!-- ...and bedtime hasn't already started (e.g., from after evening report) -->

<constraint type="propertyIsFalse" property="isBedtime"/>

<!-- ..and only if evening report has been completed today -->

<constraint type="timeSinceEvent" log="completed" logItemId="evening_report"
hours="12" negate="true"/><link taskid="set_alarm_time"/><logic type="setProperty"
property="isBedtime" value="true"/><logic type="log" log="bedtime started"/><message
text="Please remember to charge device overnight. Thank you, good
night."/></action></menu>

<prompts><action id="random_prompt_action" name="Random Prompt"><parameter
name="promptMessage" value="Interview is ready."/><parameter
name="promptLength" value="240"/><parameter name="allowDelay"
value="true"/><parameter name="delayLength" value="120"/><constraint
type="propertyIsFalse" property="isBedtime"/><constraint
type="randomTime"><parameter name="windowSize">290</parameter><parameter
name="buffer">15</parameter></constraint><group><survey
```

id="random_prompt"><question id="satisfy" type="slider" text="Was your last food/drink satisfying?" maxLabel="Yes!!" minLabel="No!!"/><question id="more_less" type="radiobutton" text="How much did you consume?"><answer text="More than usual"/><answer text="Same as usual"/><answer text="less than usual"/></question>

<!-- <message text="RIGHT NOW FEELING:"/> -->

<logic type="setProperty" property="header" value="FEELING: "/><link taskid="feeling"/>

<!--<message text="RIGHT NOW: "/> -->

<logic type="setProperty" property="header" value="RIGHT NOW: "/><link taskid="location_regulation_social_activities_consumption"/><link taskid="current_craving"/><link taskid="advertisements"/><message text="Last chance to go back. Push arrow to complete"/></survey><message text="Thank you, good bye."/></group></action><action id="evening_report_alarm_action" name="Evening Report Alarm"><parameter name="promptMessage" value="The evening report has not been completed"/><parameter name="promptLength" value="120"/><parameter name="allowDelay" value="false"/><constraint type="timeSinceEvent" log="completed" logItemId="evening_report" hours="12"/><constraint type="group" selection="or"><constraint type="timeWindow" endTime="2115" startTime="2100"/><constraint type="timeWindow" endTime="2215" startTime="2200"/></constraint></action><action id="wake_alarm_action" name="Wake Alarm"><parameter name="promptMessage" value="Time to wake up!"/><parameter name="promptLength" value="300"/><parameter name="allowDelay" value="true"/><parameter name="delayLength" value="180"/><constraint type="propertyIsTrue" property="isBedtime"/><constraint type="timeSinceEvent" log="completed" logItemId="wake_report_action" hours="12"/><constraint type="timeWindow"><parameter type="property" name="startTime" property="wakeAlarmTime"/><parameter type="sum" name="endTime"><parameter type="property" property="wakeAlarmTime"/><parameter value="60"/></parameter></constraint><link taskid="end_bedtime"/><link taskid="wake_report"/><message text="Thank you, good bye."/></action></prompts><forced> </forced><background><action id="end_sleep_action" name="End Sleep"><constraint type="propertyIsTrue" property="isBedtime"/><constraint type="timeWindow"><parameter type="property" name="startTime" property="wakeAlarmTime"/><parameter type="sum" name="endTime"><parameter type="property" property="wakeAlarmTime"/><parameter value="600"/></parameter></constraint><link taskid="end_bedtime"/></action></background><administrator/></actions><tasks><question id="set_alarm_time" type="time" text="Set your wake-up alarm:" maxValue="1200" minValue="500" saveAnswerTo="wakeAlarmTime"/><group id="end_bedtime"><logic type="setProperty" property="isBedtime" value="false"/><logic type="log" log="bedtime ended"/></group><group id="current_craving"><question id="craving_any" type="radiobutton" text="Are you craving any food right now?"><answer text="Yes"><question id="craving" type="slider" text="Craving intense?" maxLabel="Yes!!" minLabel="No!!"/><question id="craving_what" type="checkbox"

text="**What food are you craving?**"><answer text="**Confectionery**"/><answer text="**Potato chips/crackers**"/><answer text="**Dried fruit/coated nuts/bars**"/><answer text="**Fruit/vegetables/nuts**"/><answer text="**Dairy products**"/><answer text="**Bakery items**"/><answer text="**Fast food**"/><answer text="**Other**"/></question></answer><answer text="**No**"/></question></group><group id="**feeling**"><question id="**good**" type="**notchedSlider**" text="**Good?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Good?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**bad**" type="**notchedSlider**" text="**Bad?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Bad?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**awake**" type="**notchedSlider**" text="**Awake?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Awake?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**tired**" type="**notchedSlider**" text="**Tired?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Tired?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**nervous**" type="**notchedSlider**" text="**Nervous?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Nervous?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**calm**" type="**notchedSlider**" text="**Calm?**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Calm?</parameter></parameter><answer text="**Extremely**"/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text=""/><answer text="**Not at all**"/></question><question id="**hungry**" type="**slider**" text="**Hungry?**" maxLabel="**Yes!!**" minLabel="**No!!**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Hungry?</parameter></parameter></question></group><group id="**location_regulation_social_activities_consumption**"><question id="**loc**" type="**radiobutton**"><parameter type="**concatenate**" name="**text**"><parameter type="**property**" property="**header**"/><parameter>Location?</parameter></parameter><answer text="**Home**"/><answer text="**Workplace**"/><answer text="**Other's home**"/><answer text="**Bar**"/><answer text="**Restaurant**"/><answer text="**Vehicle**"/><answer text="**Outside**"/><answer text="**Between places**"/><answer text="**Other**"/></question><question id="**food_avail**" type="**checkbox**"><parameter

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type="concatenate" name="text"><parameter type="property"
property="header"/><parameter>Food available?</parameter></parameter><answer
text="None" exclusive="true"/><answer text="Confectionery"/><answer text="Potato
chips/crackers"/><answer text="Dried fruit/coated nuts/bars"/><answer
text="Fruit/vegetables/nuts"/><answer text="Dairy products"/><answer text="Bakery
items"/><answer text="Fast food"/><answer text="Other"/></question><question
id="outlet" type="checkbox" text="From where you are NOW, can you walk to (<5mins)
or see any ..."><answer text="None" exclusive="true"/><answer text="Fast food
outlets"/><answer text="Restaurants"/><answer text="Supermarkets"/><answer
text="Convenience Stores"/><answer text="Chemists or Bargin Shops"/><answer
text="Bakeries"/></question><logic type="setProperty" property="isAlone"
value="false"/><question id="with_others" type="checkbox"><parameter
type="concatenate" name="text"><parameter type="property"
property="header"/><parameter>With others?</parameter></parameter><answer
text="Alone" exclusive="true"><logic type="setProperty" property="isAlone"
value="true"/></answer><answer text="Friends"/><answer
text="Acquaintances"/><answer text="Family members"/><answer text="Co-
workers"/><answer text="Romantic partner"/></question><question id="oth_eat_dr"
type="checkbox"><parameter type="concatenate" name="text"><parameter
type="property" property="header"/><parameter>People
eating/drinking?</parameter></parameter><answer text="No" exclusive="true"/><answer
text="Yes, in my group"/><answer text="Yes, in view"/></question><question
id="activity" type="radiobutton"><parameter type="concatenate"
name="text"><parameter type="property"
property="header"/><parameter>Activities?</parameter></parameter><answer
text="Working/chores"/><answer text="Inactive/leisure"/><answer text="Interacting with
others"><question id="interaction" type="radiobutton" text="Type of interaction with
others"><answer text="Socializing"/><answer text="For business"/><answer
text="Household issues"/><answer text="Arguing"/><answer text="Other
interaction"/></question></answer><answer text="Between activities"/><answer
text="Other activities"/></question></group><group id="advertisements"><question
id="adverts" type="checkbox" text="From where you are now, what food or beverage-
related advertisements can you see?"><parameter
name="questionLines">3</parameter><answer text="None" exclusive="true"/><answer
text="Media ads"><question id="media_ads" type="radiobutton" text="Type of media
ad?"><answer text="TV"/><answer text="Radio"/><answer text="Social media"/><answer
text="Other"/></question></answer><answer text="Poster ads"><question id="poster_ad"
type="radiobutton" text="Type of poster ad?"><answer text="Billboards"/><answer
text="Other outdoor signs"/></question></answer><answer text="Ads on
vehicles"><question id="vehicle_ads" type="radiobutton" text="Type of
vehicle?"><answer text="Food vans"/><answer text="Trucks"/><answer
text="Cars"/><answer text="Buses"/><answer
text="Other"/></question></answer><answer text="Other"/></question></group><survey
id="wake_report" name="Wakeup Report"><logic type="setProperty"
property="showWakeMessage" value="true"/><question id="wut" type="radiobutton"
text="Good Morning! How long ago did you wake up?"><answer text="<15
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mins"/><answer text="**15-30 mins**"/><answer text="**30-60 mins**"/><answer text="**>60 mins**"/></question><message text="**RIGHT NOW FEELING:**"/><question id="**m_hunger**" type="**slider**" text="**Hungry?**" maxLabel="**Yes!!**" minLabel="**No!!**"/></survey></tasks></emastudy>

Appendix E

EMA Device User Manual

YOUR ELECTRONIC DIARY

This guide will give you information on what to expect when using your electronic diary

Contents

Your role as a participant

During your study participation, please:

- Carry the device with you **all day, every day**
- Respond to all the prompts/beeping
- Log every food and drink intake **in real time**; i.e. just before or while you are actually eating.
- Log **every** food and drink that you consume during the course of the study
- Conclude your day with the **Evening Report and Bedtime Report (setting the alarm)**

It is important for us to know:

- When you eat/ drink
- What the trigger is for you to eat/ drink
- Where you are when you eat/ drink
- What you are doing
- And how you are feeling

Please don't log food and drink intake after you have consumed them or add in meals/ snacks to make up for ones missed. We want to know about the food/ drink you are consuming now.

Getting started

Slide the green lock symbol on the left side of the screen to unlock the device and enter the program.

When you first awake in the morning complete the **morning report**. It will appear as a survey from the time the alarm was set.

Completing this is important so we can see your sleep/wake cycle and your food and drinking patterns.

How to record a meal/drink

We would like you to tell us about **everything you eat and drink**, as you eat/drink it.

To do this, use the touch screen and select either FOOD or DRINK

The device will sometimes follow up your entry log with a brief set of additional questions.

However, other times the device may simply tell you that your entry has been logged and return straight to the Survey Menu without asking further questions.

Responding to surveys

If additional questions are asked after you have logged your food or drink, there are several different ways you may be required to respond.

For questions that provide you with separate categories or response questions, use the touch screen to click on the box(es) that corresponds to the appropriate response (more than one option may be possible).

For questions that ask you to rate your current feelings or level of agreement, either tap the meter and slide it up or down to the desired level, or you can simply tap anywhere on the screen that is in line with the level you would like to select on the meter.

For questions requiring you to insert a quantity as your answer, tap on either the minus '-' or the plus '+' buttons to adjust the number in the middle to the appropriate level.

Hit CONTINUE to proceed to the next question.

If you begin a survey and then get interrupted or distracted and stop responding, the survey will time-out and a message will appear on the screen prompting you to RETURN TO SURVEY. If you do not resume the survey within 15 seconds, you will automatically be returned to the main menu and the survey will be recorded as missed.

Random prompts/beeping

To compare with your food/drink assessments, we need to know what you do and how you feel etc., when you are not eating/drinking.

Therefore, you will receive a prompt several times a day for a non-eating/drinking assessment.

The device will start beeping/vibrating when an assessment is ready.

The device will beep for 60 seconds. Slide the tick icon to the right to answer the assessment questions.

You can delay answering a random prompt survey for two minutes. If it is not completed within that time the assessment will time out.

It is therefore important that you carry the device with you at all times.

Suspending the device

At times you may be unavailable to respond to random prompts. To avoid missing surveys when you are unable to attend to the device, you have the option of putting the device on suspend.

To do this, hit the SUSPEND button at the bottom of the main Survey Menu.

A menu will appear where you have the option of suspending the phone for 15mins, 30mins, 60mins, 90mins or 120mins.

When the chosen time frame is up, the device will automatically go back to active mode. To return to active mode sooner, hit END SUSPEND at the bottom of the main menu screen.

Evening reports

An evening report is a summary of your day in general. This is important for us to gain an overview of how you viewed your day.

Between **7pm and midnight each day**, an additional option will appear in the survey menu titled EVENING REPORT.

Please select this option and answer the short questionnaire about your day.

After the EVENING REPORT is completed there is a brief BEDTIME report where the device gets you to set an alarm for the next day.

Set the alarm from the time you want to start recording again, perhaps just prior to your usual breakfast time.

You can check the alarm time by selecting CHECK/ EDIT ALARM

Please remember to charge the device overnight.

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SCHOOL OF MEDICINE, PSYCHOLOGY

Thank you for helping research into diet and nutrition. We value your time and contribution in this study and information learned from your participation may be beneficial for other people by contributing to the development of future dietary management interventions.

Contact details of study team

For general enquires about the study or if you experience any technical difficulties while using the device, contact the study team on:

Email: Stefania.Franja@utas.edu.au
Phone: (03) 6226-8362